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(54) Transmitter for Generating a High-Frequency Transmission Signal

(57) The transmitter according to the invention may be used in mobile telephony systems and is characterized by low spurious signal components. A first oscillator (LO) is connected to a mixer (M1) and a comparator (PFD). The mixer (M1) is connected to a quadrature modulator (QM) which mixes the baseband input signals with the signal coming from the mixer (M1) and feeds them to a phase-frequency comparator (PFD). The output signal of the phase-frequency comparator (PFD) is filtered by a loop filter (LF) and applied to a high-frequency oscillator (HF-VCO) which directly generates the transmission signal.

[FIG]

Description

The invention relates to a transmitter for generating a high-frequency transmission signal and the use of a transmitter for a mobile telephony system. These may utilize, among others, the widely used GSM standard (Global System For Mobile Communication) or the DC1900 standard. However, the invention is not restricted to these explicitly named standards but may be employed for all communication systems in which the modulation of a carrier signal occurs such that its amplitude remains constant (phase modulation).

Like all other telecommunication networks, the GSM network consists of system components which operate interfaces and provide functionalities. It operates in the frequency ranges 890 MHz to 915 MHz and 935 MHz to 960 MHz. The network is composed of a multiplicity of radio stations. The number of modularly usable base modules in the GSM network is, however, relatively small. The base station subsystem organizes the secure exchange of data between mobile stations and the network infrastructure. Included here are the configuration, maintenance and configuration of radio links between mobile stations and the base transceiver station (base station). Additional functions performed are: a continuous quality assessment of the radio channel and the resulting reactions by the system, for example, the introduction and control of cell exchange, (handover). In addition, information is relayed about the location of the mobile station and the network. The switching subsystem first performs all tasks required for the configuration, management and disconnection of connections. In addition, the switching subsystem must also carry out all mobility-related procedures. These include the management of static subscriber data, the locating of a called mobile station at any location in the GSM provider area, and the reliable acquisition of all billing data. Additionally, the switching subsystem operates the interfaces to other telecommunications networks or telecommunications services.

The radio link between the mobile station and the network infrastructure is marked by two basic properties: The resource radio channel is available only on a limited basis. As a rule, it may be used only once at one location at the same time. Each radio channel is highly susceptible to interference. The occurrence of interference in these open systems cannot be prevented. On one physical radio channel, eight physical communication signals, called bursts, are transmitted on a time-divided basis. A complete sequence of all eight channels is called a TDMA (Time Division Multiple Access) frame. On each physical communication channel, signaling and/or useful information may be sent on so-called logical channels. The assignment of logical to physical channels is called mapping. Mapping is dynamic and changes as a function of the operating status and the transmission task to be performed, for example during the transmission of speech information over the normal burst on an existing telephone connection. The logical channels consist of traffic channels and control or check channels.

In order to transmit the signal over the air interface, a transmitter is required which processes the data signal in the baseband so that it is transmittable via the air interface. No conflicts must be created with other transmitted information coming from other radio systems. One requirement for good signal transmission quality is a low noise level sufficiently removed from the carrier and with a high transmitting power. The transmitter known from prior art and shown in Figure 1 is able to achieve this (see also *Datenblatt Telefunken* [Telefunken Data Sheet] of January 29, 1997: "Modulation PLL for GSM, DCS and PCS Systems U2893B, Application circuit (900 MHz")). This transmitter has a local oscillator LO, the function of which is channel adjustment. The signal coming from the local oscillator LO with frequency fLO is mixed by a mixer M1 with a transmission signal of frequency fVCO, coming from a high-frequency oscillator HF-VCO, and fed to a low-pass filter TP. The modulator input signal applied to

the output of the low-pass filter TP with frequency tMO is fed to a quadrature modulator QM which mixes both the in-phase data signal of frequency fI and the quadrature data signal of frequency fQ each with the modulator input signal (frequency fMO) and adds up the corresponding mixer output signals. The quadrature-modulated signal thus obtained is filtered through a bandpass filter BP and fed to a first frequency divider FT1 with a divider ratio N. The first frequency divider FT1 divides the signal with frequency fLF by the divider value N and sends the divided signal to a phase-frequency comparator PFD. The signal coming from the intermediate frequency oscillator ZF-OSZ with frequency fZF is fed to a second frequency divider FT2 with a divider value of R which divides the frequency fZF by the divider value R and feeds it to the phase-frequency comparator PFD. This comparator first compares the frequencies applied at its inputs and then their phases. The phase-frequency comparator PFD generates corresponding control output signals, usually in the form of needle pulses which are fed to a charge pump CP. The charge pump CP in connection with a passive loop filter LF functions as an active loop filter. The signal applied to the output of the loop filter LF controls the high-frequency oscillator HF-VCO which then directly generates the transmission signal with the frequency fVCO which is may be picked up at the output A of the transmitter.

The circuit arrangement described has two serious disadvantages. First, the signal generated by the mixer M1 has a high spurious signal component since both the high-frequency oscillator HF-VCO and the local oscillator LO have a significant distortion factor, that is, they generate signals with a fundamental frequency plus multiple harmonics. In addition, when changing the frequency fLO from a first to a second channel frequency, a mixing product different from the first mixing product is created – with the result that new modified spurious signal components appear at the mixer output. The frequencies of the spurious signal components may also be located very close to the transmission frequency fVCO. Secondly, interference may be emitted from the phase-frequency comparator PFD, the frequency of which may also lie in the vicinity of the transmission frequency fVCO.

The goal of the invention is to provide a transmitter in which the interference occurring in prior-art technology may be avoided, and to provide the use for the transmitter.

This goal is achieved by a transmitter according to Claim 1, and in terms of utilization, according to Claim 6.

The transmitter according to the invention for generating a high-frequency signal has a first oscillator, a mixer, a quadrature modulator, at least one frequency divider, a comparator, a first filter and a second oscillator. The output of the first oscillator is connected to the first input of the mixer and to the first input of the comparator. The output of the mixer is connected to the first input of the quadrature modulator. Baseband input signals are applied to the second and third input of the quadrature modulator. The output of the quadrature modulator is connected to the second input of the comparator, the output of the comparator to the input of the first filter, and the output of the comparator to the input of the second oscillator. The second output of the mixer is connected to the output of the second oscillator to which the high-frequency transmission signal is also applied. The frequency divided is connected between the first oscillator and the comparator, and/or between the quadrature modulator and the comparator.

Advantageously, little chip area is required for the circuit arrangement according to the invention. An additional advantage is that, through fixed frequency coupling, independent of the channel frequency, any interference occurring exactly coincides with the transmission frequency and presents no problems.

Advantageous further developments are based on the dependent claims.

For example, in one embodiment, a second filter is provided which is connected

between the mixer and the quadrature modulator.

In addition, a charge pump may be provided which precedes the first filter.

The comparator may also provide frequency comparison.

A third filter may be provided which is connected between the quadrature modulator and the comparator.

The transmitter may be employed in a mobile telephony system.

The invention is explained in more detail based on two figures.

Figure 1 shows a transmitter known from the prior art.

Figure 2 shows a block diagram of a transmitter according to the invention.

Figure 1 has already been discussed above.

Unlike the block diagram shown in Figure 1, in the transmitter shown in Figure 2 first the intermediate frequency oscillator ZF-OSZ has been removed, and secondly, the local oscillator LO has been additionally connected to the input of the second frequency divider FT2. The term "connected" in the overall context means that the individual circuit elements have been linked, either directly or with the interconnection of one or more additional circuit elements, to the second circuit element. The term "connected" designates both a functional as well as a physical connection between the individual circuit elements.

With less-complex circuitry and a lower power consumption, the transmitter according to the invention for cellular systems achieves lower broadband output noise, generates fewer undesired output signal components (for example, through undesired mixing products), and the output phase more precisely follows the desired modulation pattern than does the prior-art transmitter (Figure 1).

In contrast to the transmitter shown in Figure 1 in which the output frequency fVCO and fLO frequency change to the same degree, that is, the local oscillator lies in the channel pattern (200 KHz for GSM), the fVCO frequency changes relative to the fLO frequency as follows:

fVCC = fLO (R-N):R

The following consequences result when the local oscillator is tuned over a given range to cover the transmission band:

The fMO frequency is not constant but changes as a function of the fLO frequency weighted with the factor N:R.

The phase comparison frequency fPD is similarly detuned as a function of the fLO frequency.

The frequency pattern of the local oscillator LO is converted with a factor (R-N):R to the channel pattern of the high-frequency oscillator HF-VCO.

The critical advantage of this phase-locked coupling of all frequencies occurring in the circuit is the avoidance of spurious signal components (spurious frequencies). In the prior-art equipment of Figure 1, spurious frequencies are created as follows. In order to obtain high phase precision, the phase-frequency detector[1] PDF must be able to linearly process very small phase differences. Since the circuit in Figure 1 uses a digital phase-frequency detector PFD with a charge pump CP, this means that very short needle pulses must be generated using the phase comparison frequency fPD. In the 0/90° generation in the quadrature modulator QM, digital techniques are also employed (flip-flops) which generate very steep switching edges.

Viewed spectrally, it is always overtone spectra of these frequencies (phase comparison frequency fPD, quadrature modulator frequency fQM) which are created as a consequence of this signal processing. Due to system specifications (phase precision, both for the quadrature modulator QM and for the phase-frequency detector PFD), these circuit elements must be designed to be very fast. This means in effect that the overtone

[1] Translator's note: terms "comparator" and "detector" used inconsistently by author.

spectra have a relatively high energy content up to very high frequencies (several GHz).

The crosstalk occurring at these frequencies has the following effect on other circuit components:

Multiples of the phase comparison frequency fPD or quadrature modulator frequency fQM are converted with multiples of the frequency fLO in the mixer M1 in the vicinity of the frequency fQM. The closer this undesired mixing product approaches the frequency fQM, and thus the transmission frequency fVCO, the less it is suppressed by the transfer function of the control loop. When covering the frequency band of the local oscillator LO, there are always frequencies at which the undesired product lies very close to the desired carrier, for example, one channel separation removed. This interference product reaches an output A with a very high output level and cannot be suppressed by any known filter technique since the interference product lies within the modulating output spectrum – with the result that there is a high probability that the system specification will be violated.

The following example for GSM will show that higher-order interference products cannot be avoided:

If one chooses, for example, the ZF frequency fZF as 246 MHz and the phase comparison frequency fPD as 123 MHz, one obtains the required frequency band of the local oscillator at 1136-1161 MHz for the GSM transmission band 890-915 MHz. Harmonics of the local oscillator LO are created in the mixer M1 since for reasons of efficiency the mixer M1 operates in switching mode. The result is that 3fLO is situated in the 3408-3483 MHz band (the third harmonic is assigned the highest amplitude due to reasons of practical circuit design). At the same time, there is present in the mixer M1 a signal at 26fPD = 3198 MHz due to crosstalk effects. If the local oscillator LO is now tuned, for example, to 1147.8 MHz (one GSM channel adjacent (3198 + 246)/3 MHz), then in addition to the desired ZF carrier at 246 MHz, there is also created the mixing product at 3 · 1147.8 MHz 26 · 123 MHz = 245.4 MHz. Since the mixing has a nonlinear effect, the entire overtone spectrum of the 600 kHz intermodulation frequency is grouped around the ZF carrier.

If the intermediate frequency ZF is properly selected, the effect with 3fLO can be reduced to a low level: The covered 3fLO band must be situated "between" the harmonics of the phase comparison frequency fPD. Given a tuning band of 25 MHz required for GSM, a 3fLO band of 75 MHz and a phase comparison frequency fPD here of 123 MHz, the 3fLO band may still be centered with a frequency interval of (123 - 75)/2 MHz = 24 MHz between the fPD harmonics; however, for higher fLO harmonics this is not possible.

For technical reasons alone, the phase comparison frequency fPD cannot be raised too high.

It must be noted that even given such a frequency plan optimized for 3fLO, an intermodulation frequency is, as a rule, still created. This is, however, strongly suppressed by the loop filter LF. On the other hand, requirements to be met by the system specification increase considerably along with an increasing center frequency error for the carrier – with the result that such a "far-off spurious" can lead to a violation of specification.

The new architecture completely avoids creating these intermodulation frequencies from the outset.

A distinguishing feature of the new architecture is the fact that all frequencies occurring stand in a fixed harmonic relationship relative to each other (the linking factors were already described above).

As a result, the overtone mixing products fall precisely (phase-locked) within the carrier. Due to the unequal amplitudes of carrier and overtone mixing product, this has practically no effect on the carrier. It is therefore not possible for intermodulation frequencies to be created.

The only mechanism for creating undesired frequency components is the transfer of the phase comparison frequency fPD into

the output signal. This frequency is quite high, however, (typically 100 MHz) and has been already very strongly attenuated by the loop filter LF. Given this high center frequency error, it is possible (if needed at all) to improve the output spectrum by filtering the transmission signal.

The use of two dividers FT1 and FT2 with divider values N and R, which may be different or the same, provides a high degree of freedom in determining the frequency plan.

The circuit is based on an upconversion PLL concept.

In the event the intermediate frequency oscillator ZF-OSZ is required for the receiver, the circuit arrangement according to the invention has the advantage that the power consumption in the system (transmitter + receiver) may be reduced for the transmission process since this process does not require the intermediate frequency oscillator.

The high-frequency oscillator HF-VCO is a voltage-controlled oscillator. The local oscillator LO may also be a voltage-controlled oscillator.

Claims

1. Transmitter for generating a high-frequency transmission signal,
in which a first oscillator (LO), a mixer (M1), a quadrature modulator (QM), at least one frequency divider (FT1, FT2), a comparator (PFD), a first filter (LF) and a second oscillator (HF-VCO) are provided,
in which the output of the first oscillator (LO) is connected to the first input of the mixer (M1) and the first input of the comparator (PFD),
in which the output of the mixer (M1) is connected with the input of the quadrature modulator (QM),
in which baseband input signals are applied at the second and third inputs of the quadrature modulator (QM),
in which the output of the quadrature modulator (QM) is connected with the second input of the comparator (PFD),
in which the output of the comparator (PFD) is connected with the input of the first filter (LF),
in which the output of the first filter (LF) is connected to the input of the second oscillator (HF-VC),
in which the second input of the mixer (M1) is connected to the output of the second oscillator (HF-VCO) to which the high-frequency transmission signal is also applied,
in which the frequency divider (FT1, FT2) is connected between the first oscillator (LO) and the comparator (PFD) and/or between the quadrature modulator (QM) and the comparator (PDF).

2. Transmitter according to Claim 1, in which a second filter (TP) is provided which is connected between the mixer (M1) and the quadrature modulator (QM).

3. Transmitter according to one of Claims 1 or 2, in which a charge pump (CP) is provided which precedes the first filter (LF).

4. Transmitter according to one of Claims 1 through 3, in which the comparator (PFD) is also employed for frequency comparison.

5. Transmitter according to one of Claims 1 through 4, in which a third filter (BP) is provided which is connected between the quadrature modulator (QM) and the comparator (PFD).

6. Use of the transmitter according to one of Claims 1 through 5 for a mobile telephony system.

1 page of drawings attached